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RECORD OF DECISION

for

LANDFILL 4
and the
SOLVENT REFINED COAL PILOT PLANT

FORT LEWIS MILITARY RESERVATION, WASHINGTON

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DECLARATION OF THE RECORD OF DECISION

SITE NAMES AND LOCATION

Landfill 4 and the Solvent Refined Coal Pilot Plant
Fort Lewis Military Reservation
Pierce County, Washington

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial actions for two sites, Landfill 4 (LF4) and the Solvent Refined Coal Pilot Plant (SRCPP), located on the Fort Lewis Military Reservation, Pierce County, Washington. The selected remedial actions for each site were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. Selection of each remedial action is based on the administrative record for the sites.

All investigative activities at these sites were conducted under a Federal Facility Agreement entered into by the U.S. Army, U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology), pursuant to Section 120(e) of CERCLA. The lead agency for this decision is the Army. EPA approves of these decisions and, along with Ecology has participated in the scoping of site investigations, evaluation of data, and analysis of remedial alternatives. The State of Washington concurs with the selected remedies.

ASSESSMENT OF THE SITES

Actual or threatened releases of hazardous substances from these sites, if not addressed by implementing the response actions selected in this Record of Decision, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDIES

The selected remedy for LF4 includes treatment of suspected sources of groundwater contamination, treatment of contaminated groundwater, groundwater monitoring, and implementation of institutional controls to protect human health and the environment during remedial action. Major components of the LF4 selected remedy include:

- Installing an active soil vapor extraction system (VES) in suspected groundwater contamination source areas. Vapors from the system will be treated in compliance with air quality regulations prior to discharge.

- Installing an in situ groundwater sparging system to remove volatile contaminants from groundwater. The sparging system will work in conjunction with the VES.

- Monitoring upper aquifer groundwater to determine the effectiveness of the selected remedy.

As part of the monitoring program, the localized area of elevated manganese along the western borders of South and Northwest LF4 will be monitored to determine any changes in manganese concentrations. If the monitoring indicates that manganese concentrations are not declining, the need for remediation of the localized area will then be reevaluated. This reevaluation may include supplemental sampling, or additional source characterization.

- Maintaining institutional controls restricting access to and development at the site as long as hazardous substances remain onsite at levels that preclude unrestricted use.

The selected remedy for the SRCPP includes excavation and treatment of contaminated soils, groundwater monitoring, and institutional controls to protect human health and the environment during remedial action. Major components of the SRCPP selected remedy include:

- Excavating and treating contaminated soils. Soils will be treated using either soil washing or low temperature desorption to meet cleanup levels.

- Monitoring upper aquifer groundwater beneath and adjacent to the site to determine the effectiveness of the selected remedy.

- Maintaining institutional controls restricting access to and development at the site as long as hazardous substances remain onsite at levels that preclude unrestricted use.

STATUTORY DETERMINATIONS

The selected remedies are protective of human health and the environment, comply with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial actions, and are cost-effective. The remedies utilize permanent solutions and alternative treatment technologies to the maximum extent practicable, and satisfy the statutory preference for remedies that employ treatment that reduces contaminant toxicity, mobility, and volume as a principal element.

A review will be performed not less often than every five years after initiation of the final response actions, as long as hazardous substances remain onsite at levels that preclude unrestricted use.

Signature sheet for the foregoing Fort Lewis Landfill 4 and the Solvent Refined Coal Pilot Plant Record of Decision between the U.S. Department of the Army and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

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DECISION SUMMARY

I. INTRODUCTION

This decision summary addresses two sites, Landfill 4 (LF4) and the Solvent Refined Coal Pilot Plant (SRCPP), both located on the U.S. Army's Fort Lewis Military Reservation (Fort) in western Washington State. The two sites lie within a common study area, shown on Figure 1. The relationship of the two sites is shown on Figure 2.

An installation-wide Federal Facility Agreement (FFA), Administrative Docket Nos. 1088-06-16-120 and 1089-09-23-120, between the U.S. Army (Army), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) became effective January 29, 1990. The FFA establishes a procedural framework for agency coordination and a schedule for all Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund), as amended by the Superfund Amendments and Reauthorization Act of 1986, activities conducted at Fort Lewis.

Pursuant to Executive Order 12580 (Superfund Implementation) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Army performed a Remedial Investigation/Feasibility Study (RI/FS) for LF4 and the SRCPP. The Remedial Investigation (RI) (1993) characterized contamination in the air, groundwater, sediments, surface water, and soil. The Baseline Risk Assessment (RA) (1993) evaluated potential effects of the contamination on human health and the environment. The Feasibility Study (FS) (1993) evaluated alternatives for remediating contamination. In accordance with section 120(e)(2) of CERCLA, the Army will begin the remedial action within 15 months of completion of the RI/FS process.

Following Section II (Highlights of Community Participation), the decision summary is organized by site. Thus, the LF4 summary is presented first, followed by the SRCPP summary.

II. HIGHLIGHTS OF COMMUNITY PARTICIPATION

A. COMMUNITY RELATIONS DURING THE RI/FS

A community relations plan (CRP) was prepared in 1992 as part of the management plan for LF4 and the SRCPP. The CRP was designed to promote public awareness of the investigations and public involvement in the decision-making process.

Local citizens and public officials were interviewed to identify potential issues and concerns associated with LF4 and the SRCPP. This information was used to focus the CRP to meet the specific needs of the local communities and to guide development and implementation of the RI/FS.

In February 1993, a Community Information Update newsletter was prepared and distributed, which described the RI/FS work underway at LF4 and the SRCPP.

To promote community awareness of RI/FS activities, information repositories containing site documents were established at the Pierce County Library (Lakewood Branch and Tillicum Branch) and Fort Lewis (Directorate of Engineering and Housing, Environmental and Natural Resources Division).

Also, in accordance with section 113 of CERCLA, an administrative record was established to provide the basis for the selected remedies. The administrative record is available for public review at the Fort Lewis Environmental and Natural Resources Division.

B. COMMUNITY RELATIONS TO SUPPORT SELECTION OF REMEDY

In accordance with sections 117 and 113(k)(2)(B) of CERCLA, the public was given the opportunity to participate in the remedy selection process. The proposed plan, which summarized the alternatives evaluated and presented the preferred alternatives, was mailed to approximately 250 interested parties in May 1993. The Army provided public notice through a display ad in the Tacoma News Tribune and the Northwest Guardian to explain the proposed plan, list the public comment period, and announce the public meeting.

A 30-day public comment period was held from May 31 to June 30, 1993. No requests for extensions were received during the comment period. Approximately 10 community members attended the open house/public meeting, which was held on June 15, 1993 in the DuPont City Hall/Community Center. Three written comments were received. Responses to these comments are included in the Responsiveness Summary.

A fact sheet summarizing the Record of Decision (ROD), public comments, and the Army's response will be mailed to interested parties on the mailing list after the ROD is signed. Copies of the ROD and the Responsiveness Summary will be placed in the administrative record and in the information repositories.

III. LANDFILL 4

A. SITE NAME, LOCATION, AND DESCRIPTION

LF4 occupies approximately 52 acres on the North Fort portion of Fort Lewis. As shown on Figure 2, Vancouver Road bisects the landfill into two approximately equal sections, north and south. The north section is further divided into two parts by an unimproved dirt road. These two parts are designated Northeast and Northwest LF4. The south section of the landfill is designated South LF4.

Northeast LF4 is covered with low relief grasses, shrubs, and scattered deciduous and coniferous trees in its southern portion. Unimproved dirt roads traverse the surface of Northeast LF4, but vehicle traffic appears limited. Surface elevations range from approximately 225 to 240 feet above Mean Sea Level (MSL). The central portion of Northeast LF4 is depressed relative to the surrounding topography.

Northwest LF4 is covered with low relief grasses and shrubs. A large, post-closure, irregularly shaped berm with an inner depression lies just north of Vancouver Road. The berm's sides are covered with brush and show some exposed refuse. Other than the earthwork and a relatively small, post-closure excavation on its western boundary, Northwest LF4 is relatively flat. Surface elevations range from 235 to 245 feet above MSL, matching the surrounding topography.

South LF4 is covered with low relief grasses and scattered deciduous and coniferous trees. Unimproved dirt roads also traverse this section of the landfill. South LF4 surface elevations typically range from approximately 230 to 235 feet above MSL. Portions of the southeast and western boundaries slope steeply downward to match relatively depressed natural topography.

Surface water bodies within the study area include the western portion of Sears Lake, the southwestern tip of American Lake, Sequalitchew Lake, Sequalitchew Springs, Sullivan Well, Sequalitchew Creek, Hamer Marsh, and a small forested wetland west of South LF4. These features are shown on Figure 2.

Land uses around LF4 include residential to the east, military to the west, north, and east, and recreational to the south adjacent to Sequalitchew Lake. No residences or offices are located directly adjacent to the landfill. However, some military training exercises take place on or adjacent to the landfill. General surrounding land use is indicated on Figure 3.

The Fort's primary water sources, Sequalitchew Springs and Sullivan Well, are both located within the study area as shown on Figure 2. Water from the Springs is adequate to meet current Fort demand during the winter, but is frequently supplemented by Sullivan Well and other sources during the summer due to higher demand.

Sequalitchew Springs has been the primary source of drinking water for the Fort since its inception. Sequalitchew Springs is currently covered by a concrete-walled and roofed structure. At its closest approach, LF4 lies approximately 1,350 feet northwest of the Springs.

Sullivan Well (also referred to as wells 12A and 12B) is a developed spring comprising two adjacent, shallow, dug wells used to supplement Sequalitchew Springs water production during periods of high demand. Sullivan Well is located approximately 1,800 feet south of the Springs.

Water supply wells 19A and 19B are also located in the study area. These deep wells are generally not in service because they are used only as backup water supply sources.

There are no known archeological, historical, or cultural resources located on or in the vicinity of LF4. No threatened or endangered flora are known to occur on or adjacent to LF4. One federally listed threatened species, the bald eagle, has been observed within the study area; however, bald eagles do not nest on or near LF4.

B. SITE HISTORY AND ENFORCEMENT ACTIVITIES

LF4 development began in about 1951 by placing refuse in the northernmost of two gravel pits between Vancouver Road and 41st Division Drive. Landfilling was expanded to the south and west of the original pit, forming Northeast and Northwest LF4, until approximately 1961. Gravel mining continued in the southern pit until the late 1970s.

Landfilling extended to the area south of Vancouver Road (South LF4) in 1961, and continued there until about 1967. All three landfill sections were closed by covering with gravel, which was graded into a series of parallel furrows to promote surface water runoff and check erosion.

Although there are no landfilling records, the waste materials probably consisted of domestic and light industrial solid waste (including domestic liquids and biosolids collected by septic tank pump trucks) and construction debris. Refuse thickness likely ranges from approximately 9 to as much as 20 feet. A 1960 aerial photograph shows several aboveground storage tanks, vehicles, a gravel screen plant, and other unidentified equipment south of Northeast LF4, and several small buildings, a potential liquid waste disposal pit, and other vehicles and equipment near the western edge of Northeast LF4. A 1966 aerial photograph shows several small buildings and a circular pit, similar to those noted on the 1960 photograph at Northeast LF4, located on South LF4.

A 1988 investigation of LF4 by Battelle's Pacific Northwest Laboratory (PNL) indicated shallow groundwater around the landfill was contaminated by several chlorinated hydrocarbons, principally trichloroethene (TCE), at concentrations ranging from 1 to 32 micrograms per liter (ug/L). The highest TCE concentration was detected in a monitoring well (PNL3) located between LF4 and Sequalitchew Springs.

Water quality data for Sequalitchew Springs, Sullivan Well, and wells 19A and 19B was obtained for the years 1986 through 1989. Sequalitchew Springs is tested quarterly and Sullivan Well, Well 19A, and Well 19B yearly for volatile organic compounds (VOCs), corrosivity, inorganic compounds, and total trihalomethanes. Several VOCs considered to be chlorination byproducts were detected in the treated water from Sequalitchew Springs and Sullivan Well.

Based on the FFA and the results of PNL's 1988 sampling, an RI/FS was initiated at LF4 in 1991. The RI/FS characterized the nature and extent of contamination, assessed site risks to human health and the environment, and evaluated remedial alternatives.

C. SCOPE AND ROLE OF RESPONSE ACTION WITHIN SITE STRATEGY

The selected remedy is intended to address all unacceptable risks resulting from contamination at LF4. It reduces risks associated with potential exposure through treatment of likely sources of ongoing groundwater contamination within soil and direct remediation of contaminated groundwater.

Institutional controls are included to prevent construction of new water supply wells and residences on or near LF4. Long-term groundwater monitoring will verify the effectiveness of the selected remedy.

D. SUMMARY OF SITE CHARACTERISTICS

1. Geology and Hydrogeology

LF4 is situated on a glacial drift plain. The elevation of the plain in the vicinity of the landfill is 200 to 250 feet above MSL. Major features of relief in the study area are several kettles (glacial-derived depressions) which include Sequalitchew, Sears, and American Lakes.

Geologic and hydrogeologic conditions in the study area were investigated by drilling 20 borings and completing them as groundwater monitoring wells. Stratigraphic correlations between boreholes were made and six stratigraphically distinct deposits were identified underlying LF4 as shown in Figure 4. The uppermost formation, the Vashon Drift, is approximately 75 feet thick and consists of gravels, silty gravels, and sand. Beneath the Vashon Drift is the Discovery Nonglacial Unit, which consists of sands and silty sands ranging in thickness from approximately 30 to 70 feet. The Discovery Nonglacial Unit appears to be depositionally absent beneath portions of northeast and northwest LF4. Beneath the Discovery Nonglacial Unit, or the Vashon Drift where the Discovery Nonglacial Unit is absent, is the Narrows Glacial Unit which consists primarily of lodgement till and sandy gravel outwash, ranging in depth from approximately 5 to 80 feet. Underlying the Narrows Glacial Unit is the Kitsap Formation which ranges in thickness from approximately 10 to 45 feet and generally occurs as a fine-grained sand and a silt with sand and peat interbeds. Because of its fine-grained character, the Kitsap Formation is generally considered a regional aquitard. Underlying the Kitsap Formation is the Flett Creek Glacial Unit, which ranges in thickness from 70 to 85 feet and consists of a very dense, unsorted gravel with silt and sand (lodgement till), underlain by a coarse grained sandy gravel (outwash). Beneath the Flett Creek Glacial Unit is the Clover Park Nonglacial Unit, which was over 100 feet thick in the deepest boring, and included sandy gravel, sand, and silt.

Two aquifers and two aquitards were defined beneath the site. The upper aquifer occurs under unconfined (water table) conditions within the Vashon Drift, Discovery Nonglacial Unit, Narrows Glacial Unit gravel outwash, and Kitsap Formation sand throughout the study area. The water table depth varies from 0 to a maximum of about 42 feet below ground surface (bgs). It is generally 15 to 25 feet bgs near LF4.

Narrows Glacial Unit lodgement till, located within the upper aquifer near the north edge of south LF4, effectively divides the aquifer into upper and lower parts in that area. This till body is termed the upper aquitard.

The upper aquifer is separated from the underlying lower aquifer by a middle aquitard which is a widespread, low-permeability deposit of Kitsap Formation silt and peat, and Flett Creek Glacial Unit till. The middle aquitard is apparently effective in separating the two aquifers since hydraulic heads in the lower aquifer are consistently 100 to 125 feet lower than in the upper aquifer.

Groundwater in the lower aquifer occurs under confined conditions beneath the middle aquitard, within the Flett Creek Glacial Unit outwash and the more permeable fractions of the Clover Park Nonglacial Unit.

Groundwater in the upper aquifer is recharged by direct, rapid infiltration of rainfall and by subsurface flow from American and Sequalitchew Lakes. Groundwater flow from the east and south typically meets in the vicinity of LF4 and continues to the north/northwest. RI chemical distribution data indicate some westward flow beneath LF4 as well. The upper aquitard appears to act as a hydraulic dam, creating a large area of extremely flat hydraulic gradients between it and Sequalitchew Lake. This flat area is essentially a subsurface extension of the lake.

Pumping at Sequalitchew Springs depresses the water table and reverses groundwater flow directions in the area southeast of LF4. Under nonpumping conditions, groundwater flows from beneath South LF4 to the west and north. Under pumping conditions, part of this flow diverts to the southeast toward Sequalitchew Springs. Groundwater flow, at the lowest water elevations observed during the study period, is shown on Figure 5.

Upper aquifer hydraulic conductivity estimates, derived from single borehole permeability tests and grain size analyses, range from 0.28 feet per day (ft/day) to 1,420 ft/day. Estimated horizontal flow velocities range from 1.2 feet per year (ft/yr) to 4,029 ft/yr; the higher velocities occur for westward flow between American and Sequalitchew Lakes, while the lower velocities represent north/northwest flow from Sequalitchew Lake under South LF4. Estimated horizontal flow velocities between Northeast LF4 and Sequalitchew Springs range from 25.8 to 258 ft/yr, resulting in a travel time from Northeast LF4 to Sequalitchew Springs of 5 to 50 years. Groundwater modeling results indicate that under maximum pumping rates, approximately 1 percent of the water entering Sequalitchew Springs flows through the vicinity of Northeast LF4.

Lower aquifer groundwater flow is generally from east to west across the site, ultimately discharging to Puget Sound. Lower aquifer hydraulic conductivity estimates range from 14 to 142 ft/day. Lower aquifer groundwater velocities and travel times were not estimated because as discussed below, LF4 does not appear to impact the lower aquifer.

2. Nature and Extent of Contamination

The RI evaluated potential LF4 impacts to air, groundwater, surface water, and soil. The investigation revealed that there is no surface water or groundwater movement towards Sequalitchew Lake. It was also determined during the investigation that soil hot spots adjacent to LF4 are the suspected source of groundwater contamination. These soil hot spots will be discussed in the section Groundwater below.

a. Air

Landfill gases were evaluated by ambient air and passive gas surveys. Twenty gas probes were installed within and around the landfill (refer to Figure 6 for gas probe locations). Samples were collected on two separate occasions and were analyzed for atmospheric gases (e.g., oxygen, methane, nitrogen) and VOCs. Table 1 summarizes the analytical results for landfill gas samples collected during the RI.

The RI revealed that methane production at LF4 is low and expected to decrease further due to the landfill's age. Chlorinated ethenes were not detected in ambient air samples collected above the landfill surface.

Qualitative, passive gas survey results indicate areas of elevated tetrachloroethene (PCE) and TCE flux rates (movement rates) both on and around LF4. The highest flux rates were measured near monitoring well MW8, in two Northeast LF4 areas, and in South LF4 where it borders Vancouver Road. Other areas of elevated PCE and TCE flux were located near the center of South LF4, along the northeastern border of South LF4, and within the central portion of Northeast LF4.

Low concentrations of vinyl chloride (VC) and dichloroethene (DCE) were detected in gas probes completed within the landfill. VC was detected in three areas: the central portion of South LF4 at a maximum concentration of 0.47 milligrams per cubic meter (mg/m^3); the southeastern edge of South LF4 at a maximum concentration of 2.4 mg/m^3; and in the central portion of Northeast LF4 at a maximum concentration of 4.1 mg/m^3. DCE was detected at the northern tip of Northeast LF4, and in one location on the southeastern border of South LF4. The maximum detected DCE concentration was 0.20 mg/m^3.

TCE was detected in three gas probes completed in native soil adjacent to LF4. The highest soil gas levels of TCE were detected directly south of Northeast LF4 (concentrations of 1.6 mg/m^3), coincident with an elevated TCE flux area detected by passive gas survey methods. VC, DCE, and PCE were not detected in soil gas probes.

PCE and TCE are suspected human carcinogens, VC is a known human carcinogen, and DCE is a noncarcinogenic toxicant. PCE and TCE are commonly available degreasing solvents and were used historically at the Fort. DCE and VC are not available in pure form except within the chemical industry: they are present at LF4 only as breakdown products of PCE and TCE.

PCE, TCE, DCE, and VC are broken down by the same microbial processes responsible for landfill gas generation.

b. Groundwater

Groundwater samples were collected from 30 upper aquifer and 7 lower aquifer monitoring wells during March and June, 1992. Refer to Figure 7 for well locations. The two sampling rounds were timed to approximate "wet" and "dry" season conditions. All samples were analyzed for VOCs, semivolatile organic compounds (SVOCs), metals, polychlorinated biphenyls, pesticides, and general groundwater quality indicator parameters such as major anions and chemical oxygen demand. Table 2 summarizes the analytical results for groundwater samples collected during the RI.

Several organic contaminants were detected in the lower aquifer at concentrations below their respective drinking water standards. Evaluation of this data indicated that, since these contaminants were not detected in the upper aquifer, they are not associated with LF4. Therefore, the lower aquifer will not be discussed further.

TCE, DCE, and VC were detected in groundwater beneath the site. TCE was detected in the uppermost part of the upper aquifer (upper aquifer upper part) in 15 of 22 monitoring wells. The highest TCE concentrations were measured in wells near the western tip of South LF4 and the southern tip of Northeast LF4. Groundwater monitoring wells LF4-1, -MW5, - MW8A, and -PNL3 have the highest TCE concentrations (6 to 79 g/L). DCE in the upper aquifer -upper part was detected principally in wells adjacent to, or downgradient from, the landfill. Maximum detected DCE concentration was 5.0 ug/l at MW8A, coincident with the highest TCE concentrations. VC was detected only once in the upper aquifer upper part, directly east of the forested wetland adjacent to the western edge of South LF4 at an average concentration of 4 ug/l. Figure 8 shows the distribution of chlorinated ethenes in the upper aquifer-upper part. DCE and VC, but not TCE or PCE, were detected in the upper aquifer-lower part. Both compounds were detected between the South and Northwest portions of LF4; only VC was detected further downgradient.

As previously discussed, historical aerial photographs show two suspected liquid waste disposal pits in Northeast and South LF4. The photographs also indicate equipment operation, storage, and maintenance activities associated with gravel pit operations adjacent to the southern part of Northeast LF4. Historically, PCE and TCE were widely used as degreasing solvents; vehicle maintenance operations may have included degreasing, leading to surface release of PCE and TCE. Passive soil gas, gas probe, and groundwater data indicate elevated levels of chlorinated ethenes in the vicinity of the likely equipment operation and maintenance activities and the two waste pits identified on the aerial photographs.

TCE (and/or PCE) disposed of outside the boundaries of LF4 would likely still exist as TCE unless an anaerobic (oxygen-deficient) environment developed at the point of disposal. The TCE would partition onto soil particles, into underlying groundwater, into infiltrating rainwater, and into the ambient air. Normally, TCE would not long remain in the coarse surface soils surrounding LF4. However, if the TCE were codisposed with oils and grease (from degreasing operations), the less mobile oils and grease would act to retain part of the TCE in the near-surface soils.

As a result of disposal, whether recent or historic, TCE has likely partitioned into the unsaturated zone soil at various concentrations. This TCE-contaminated soil (also referred to as a "hot spot") likely acts as a source of groundwater contamination.

Current impacts to groundwater beneath LF4 are likely the result of volatile contaminants in the soil reaching groundwater. Infiltration of surface water and precipitation through the surrounding soils appear to be a secondary mechanism for transport of contaminants to groundwater.

Groundwater quality data for the upper aquifer indicate low levels of major metals and inorganic compounds are being leached from LF4 into the upper aquifer. Leachate intrusion into the upper aquifer is marked by increased specific conductance, alkalinity, dissolved major metals including iron and manganese, dissolved arsenic, and biochemical oxygen demand.

Manganese was elevated above background along the western borders of South and Northwest LF4. Manganese concentrations are significantly lower in wells further downgradient of LF4. Results of the RI indicate that the elevated concentrations of manganese in groundwater are caused by dissolution of manganese from geologic material in the presence of a localized area of anaerobic groundwater. As the manganese contaminated groundwater moves downgradient, the manganese appears to precipitate, as suggested by rapidly declining concentrations in immediately downgradient wells.

Sampling of upper aquifer groundwater monitoring wells south and east of LF4, between the landfill and Sequalitchew Springs, indicates no leachate impact.

E. SUMMARY OF SITE RISKS

The Baseline RA for LF4 considered human health and ecological risks. The risk assessments were conducted in accordance with EPA's Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual and Volume 2: Environmental Assessment Manual, and EPA national guidance. The RA methods and results are summarized in the following sections.

1. Human Health Risks

The human health RA evaluated potential risks associated with exposure to chemical contaminants from LF4. The assessment considered potential exposure to LF4 contaminants in air and groundwater. Soil was not included in the quantitative RA because the landfill cover precludes direct exposure to underlying contaminated soil. Sediment and surface water was also not included because Sequalitchew Lake and its sediments are not adversely affected by LF4.

Both carcinogenic (i.e., causing the development of cancer) and noncarcinogenic hazard (i.e., direct toxic effects on organ systems, reproductive and developmental effects) risks were evaluated. Risks were estimated for current and future land uses in the vicinity of LF4.

To ensure that potential health risks would not be underestimated, a conservative approach was used as recommended in EPA's guidance documents. Reasonable conservative estimates and assumptions were used to enhance confidence in the conclusions of the RA.

a. Identification of Contaminants of Concern

Contaminants of concern (COCs) were selected for LF4 based on contaminant occurrence and distribution in the environmental media and a risk-based screening approach. The COCs for LF4 are shown in Table 3.

b. Exposure Assessment

i. Exposed Populations

Exposure pathways were evaluated for the following receptors:

Current Use:
- On-site military personnel
- Military residents
- Recreationists

Future Use:
- On-site resident
- Adjacent residents
- Military residents using Sequalitchew Springs

ii. Exposure Pathways

Refer to Table 4 for the exposure pathways evaluated.

iii. Exposure Point Concentrations

Groundwater:

Average and reasonable maximum exposure concentrations were estimated based on field measurements. Groundwater exposure point concentrations were used to quantify the risks due to ingestion of drinking water, dermal absorption during household use, and inhalation of

VOCs during household use. Data from different groupings of groundwater wells were used to estimate future exposures. Sequalitchew Springs data were used for current scenarios.

The dissolved fraction of metals in groundwater was used to estimate exposure point concentrations at LF4. Total metal concentrations were considered most representative of silt conditions adjacent to the monitoring wells. Dissolved metal concentrations were considered most representative of exposure point concentrations for the ingestion of groundwater from a water supply well.

Average and reasonable maximum exposure concentrations are listed in Table 5.

Landfill Gas and Ambient Air:

Exposure to VOCs in ambient air from landfill gas emissions were estimated for specific exposure points using the SEAM diffusive model to generate landfill gas emission rates and TSCREEN to model concentrations at exposure points downwind from emissions.

Figure 9 depicts the source areas and locations of potential exposure points. Table 6 lists estimated exposure point concentrations.

Chemical Intake by Exposure Pathway:

Chemical intakes for each exposure pathway were calculated based on the exposure point concentrations and other exposure parameters such as water ingestion rates, inhalation rates, dermal absorption rates, body weights, exposure frequencies and durations. Reasonable maximum exposure calculations for the LF4 RA used values from the Standard Default Factors document (OSWER Directive No. 9285.6-03).

c. Toxicity Assessment

The toxicity assessment addresses the potential for a COC to cause adverse effects in exposed populations and estimates the relationship between the extent of exposure and the extent of toxic injury. Qualitative and quantitative toxicity information for COCs is acquired through evaluation of relevant scientific literature. The most directly relevant data come from studies in humans. Most of the useable information on the toxic effects of chemicals comes from controlled experiments in animals. Table 7 lists the toxicity values for the COCs.

Slope factors (SFs) have been developed by EPA for estimating excess lifetime cancer risks associated with exposure to potential carcinogens. SFs, which are expressed in units of (mg/kg-day)[-1], are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the SF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. SFs are derived from the results of human epidemiological studies or chronic animal bioassays to which mathematical extrapolation from high doses to low dose has been applied (e.g., to account for the use of animal data to predict effects on humans).

Reference doses (RfDs) have been developed by EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals which are likely to be without risk of adverse effect. Estimated intakes of COCs from environmental media (e.g., the amount of a COC ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans).

d. Risk Characterization

The risk characterization integrates the information developed in the toxicity assessment and exposure assessment to characterize the carcinogenic and noncarcinogenic risks associated with contaminant concentrations detected at LF4. The acceptable risk range for carcinogens is one additional chance in ten thousand (1 x 10[-4]) to one chance in one million (1 x 10[-6]) according to the NCP. Under the Washington State Model Toxics Control Act (MTCA), the maximum acceptable overall site risk from carcinogens is one chance in one hundred thousand (1 x 10[-5]) and one chance in one million for any single contaminant (1 x 10[-6]).

For noncarcinogens, acceptable levels are generally those to which the human population may be exposed during a 30 year period without adverse health effects. Noncarcinogenic risks are estimated by calculating a Hazard Index (HI). According to both Federal and State hazardous waste laws, an acceptable risk level for noncarcinogens is a HI value less than one.

Table 8 provides a summary of estimated health risks for each receptor and pathway.

e. Uncertainty

Carcinogenic and noncarcinogenic health risks were estimated in the RA for LF4 using standard assumptions; therefore, the RA results presented in Table 8 contain an inherent amount of uncertainty. The extent to which health risks can be characterized is primarily dependent upon the accuracy with which a chemical's toxicity can be estimated, and the accuracy of the exposure estimates.

Examples of uncertainty in the exposure and RA methodology used in this RA are as follows:

- The exposure scenarios assume chronic exposure to contaminant levels that do not change with time. In reality, contaminant levels often change with time in response to source loading or depletion and physical/chemical/biological forces such as chemical or biochemical degradation.

- The RA evaluated a hypothetical future residential land use scenario. Given that Fort Lewis is currently an active military installation and will remain an active installation for the foreseeable future, this scenario is very conservative.

- The sampling locations selected for the RI were biased such that potential areas of elevated concentrations would not be overlooked. Thus, risk estimates are conservative.

- The RA included arsenic as a COC for groundwater, without correction for background risk due to arsenic in groundwater. Arsenic was detected in only two wells and at concentrations very close to estimated background.

- The RA included chloroform as a COC for groundwater, without correction for its possible presence as a drinking water system chlorination byproduct.

In addition to these sources of uncertainty, the chemical analytical database has limitations in such areas as sample locations and sample representativeness. These uncertainties are present in every baseline RA.

2. Ecological Risk Assessment

An ecological RA was conducted to evaluate the potential adverse impacts to plants and animals resulting from exposure to contamination associated with LF4. The results of the ecological RA were intended to support management decisions on whether remedial action is required for environmental protection.

The approach used in the RA is consistent with EPA guidance for evaluating ecological risk. The basic steps were identification of COCs, assessment of potential exposure pathways, and characterization of threats to exposed biota.

a. Exposure Assessment

i. Exposed Populations

Potential receptors were identified as those plant and animal species likely to be exposed to chemicals in the landfill and the forested wetland west of the landfill. Considering the relatively small amount of wildlife habitat on the landfill, potential receptor populations are probably relatively small.

No threatened or endangered plant species are known to exist in the LF4 study area. No threatened or endangered animal species are known to nest within the LF4 study area: the bald eagle (threatened) and peregrine falcon (endangered) have been observed flying over the area. No critical habitats were identified within the study area.

ii. Exposure Pathways

The exposure assessment identified potential exposure pathways from the chemical source to the affected media, exposure points, and potential receptors. Potential exposure pathways include the air pathway for VOCs generated within LF4 and the soil pathway for the forested wetland. Groundwater was considered an unlikely pathway because the water table is normally fifteen to twenty feet bgs. Consequently, ecological receptors are not expected to come into direct contact with it.

Landfill gas emissions were considered an unlikely source of ecological risk because of the amount of dilution of the gas on mixing with air.

b. Risk Characterization

Biota inhabiting the landfill surface and those animals burrowing into landfill soils would likely not be at risk from inhalation-induced toxicity. Contaminants in landfill gas were measured at concentrations at least two orders of magnitude below levels that typically cause acute toxicity in laboratory animals.

Biota occupying the forested wetland may be exposed to low concentrations of metals and benzo[b]fluoranthene due to seasonal contact with groundwater which has discharged to ground surface. These contaminants could adhere to soil in the wetland and be present in surface waters during very high groundwater levels. As groundwater recedes during dry periods, wildlife could be exposed to these contaminants through ingestion and dermal contact routes. Exposure could only occur in the unlikely event groundwater were to discharge to the adjacent forested wetland.

c. Uncertainty

Assumptions that tend to overestimate potential exposure include the following:

- Wildlife species are continuously exposed to maximum contaminant concentrations.

- Contaminants are 100 percent bioavailable.

- Lack of analytical data for soil or surface water in the wetland habitat.

F. REMEDIAL ACTION OBJECTIVES

Remedial action is required at LF4 for TCE and VC to protect human health and the environment under potential future land use conditions. Action is required because:

- Upper aquifer groundwater beneath the site is contaminated with TCE and VC at levels exceeding State and Federal maximum contaminant levels (MCLs);

- The excess cancer risk associated with reasonable maximum groundwater exposure for potential future residential populations exceeds both Federal and State allowable risk thresholds.

Arsenic is not included because it was detected in only two wells and at concentrations that are below regulatory cleanup levels. Chloroform is not included because it is thought to be present as a drinking water chlorination by-product which has entered the aquifer through surface uses such as irrigation and vehicle washing. Manganese is not included because it is expected that the localized area of elevated concentration will rapidly decline due to implementation of the final remedy, as described in The Selected Remedy section.

Upper aquifer groundwater is the primary medium requiring action. To reduce ongoing groundwater contamination, unsaturated soil in historical disposal and/or degreasing activity areas also requires action. Remedial action objectives (RAOs) were formulated in accordance with CERCLA for each of these media. RAOs are formulated to protect human health and the environment from potential threats associated with site contaminants. RAOs for upper aquifer groundwater include:

- Prevent exposure to contaminated groundwater;

- Restore contaminated groundwater to its beneficial use, which is drinking water;

- Minimize movement of contaminants from soil to groundwater; and

- Prevent exposure to landfill contents.

Upper aquifer groundwater cleanup levels have been established to meet regulatory requirements. MTCA Method B was used to determine the cleanup level for VC at 1 ug/l, which is the practical quantitation limit (PQL)for the contaminant. The Federal MCL was used to determine the cleanup level for TCE at 5 ug/l.

G. DESCRIPTION OF ALTERNATIVES

The FS developed eight remedial alternatives to reduce site risks to human health and the environment. These eight alternatives were later consolidated into four by combining alternatives employing similar technologies.

Alternatives and the detailed analysis are discussed below.

<u>Alternative 1: No Action</u>

The no action alternative is presented as a baseline comparison for other alternatives. Under this alternative, no action would be taken to reduce contamination at LF4. A monitoring program would be implemented to monitor groundwater contamination. It is estimated that contaminant concentrations would decrease to acceptable risk levels due to natural processes in 30 years. Present worth costs are estimates at

$48,000 given a 30-year time frame.

Alternative 2: Institutional Controls

With this alternative, groundwater monitoring would continue and institutional controls would be implemented. Institutional controls may include access restrictions or further land use restrictions, in addition to existing Fort Lewis groundwater well installation restrictions. It is estimated that contaminant concentrations would decrease to acceptable risk levels due to natural processes in 30 years. A five year review and evaluation of the data gathered during the monitoring program would also be required. Present worth costs are estimated at $54,000.

Alternative 3: Soil Treatment by Vapor Extraction and Groundwater Treatment by Sparging

This alternative includes groundwater monitoring, institutional controls, and vapor extraction and sparging systems that would operate for approximately three years. A network of vapor extraction wells and a vacuum pump would be installed to extract organic contaminants from the soil. Air would be pulled through the soil subsurface and the contaminated vapor withdrawn under vacuum through screened extraction wells. The vapor extraction system (VES) would operate along with a sparging system. Sparging is the process of forcing air through perforated pipes installed in the groundwater. Contaminants would be stripped from the groundwater and subsequently collected by the VES. Contaminated vapors would be treated by a carbon filter to comply with State air quality emission standards. Spent carbon would be disposed of at an EPA-approved off-site disposal or recycling facility. Actively treating the soil hot spots to remove the source of contaminants to groundwater should reduce the time frame required to achieve cleanup standards from 30 to 15 years. Present worth costs are estimated at $2,260,000.

Alternative 4: Single Barrier Cap and Groundwater Treatment

This alternative includes groundwater monitoring and institutional controls, a single barrier cap, and groundwater extraction and treatment. The design, construction, and maintenance of the cap would meet State and Federal requirements for solid waste landfills. Emissions from a passive gas management system would be treated as necessary to ensure compliance with State air quality emission standards. Seven extraction wells would be installed and the extracted groundwater would be treated using a carbon filter unit. Spent carbon would be disposed at an off-site EPA-approved disposal or recycling facility. Treated water would be monitored and discharged either to Sequalitchew Lake or groundwater recharge trenches, dependent on cost and implementability. Primary drinking water standards should be achieved in 10 to 15 years. Present worth costs are estimated at $14,288.000.

H. SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, each alternative is compared against each other using the evaluation criteria presented below. This process allows for a full comparative analysis of each alternative. The nine criteria are categorized into three groups.

- Threshold Criteria

1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate requirements (ARARs)

- Primary Balancing Criteria

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost

- Modifying Criteria

8. State acceptance
9. Community acceptance

1. Threshold Criteria

The remedial alternatives were first evaluated in relation to the threshold criteria. The threshold criteria must be met by each alternative in order to be selected.

1. Overall Protection of Human Health and the Environment

This criterion addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

Alternatives 1 and 2 would not provide protection from potential contaminants nor prevent contaminant migration. Thus, Alternatives 1 and 2 are not protective of human health or the environment.

Alternatives 3 and 4 provide similar levels of protection. Both employ institutional controls to minimize risks during remediation. Alternative 4 may slightly reduce the time required to meet cleanup levels. Alternative 3 would address ongoing contamination by remediating suspected VOC source areas. Alternative 3 provides the greatest degree of flexibility in terms of allowing adjustment and tailoring of remedial technologies based on site-specific performance.

2. Compliance with ARARs

This criterion addresses whether or not an alternative will meet all ARARs or provide justification for invoking a waiver for one or more ARARs.

Alternatives 1 and 2 may attain Federal and State groundwater cleanup levels through natural processes (i.e., dispersion, dilution, and degradation). However, in the interim, groundwater contaminant levels would continue to exceed cleanup standards and to pose a threat to nearby Sequalitchew Springs.

Alternatives 3 and 4 will achieve compliance with ARARs and would not require waivers.

2. Primary Balancing Criteria

Once an alternative satisfies the threshold criteria, it is evaluated against five primary balancing criteria.

Alternatives 1 and 2 do not satisfy the threshold criteria since they do not provide adequate protection of human health and the environment nor comply with Federal and State environmental standards within a reasonable time frame. Because these alternatives do not satisfy threshold criteria, they are not considered further in this analysis as an option for site remediation.

3. Long-Term Effectiveness and Permanence

This criterion refers to the expected residual risk and the ability of an alternative to maintain reliable protection over time once cleanup goals have been met.

Alternatives 3 and 4 include a long-term monitoring program to ensure effectiveness, and each would require enforcement of existing institutional controls, and routine inspection and maintenance of the treatment systems. Alternative 4 would also require routine inspection and maintenance of the landfill cover.

4. Reduction in Toxicity, Mobility, and Volume through Treatment

This criterion describes the expected performance of the treatment technologies employed by an alternative.

Alternative 3 would reduce the toxicity, mobility, and volume of soil and groundwater contaminants through treatment. It employs a VES to remove contaminants from soil and sparging to remove contaminants from groundwater. It specifically addresses suspected contaminant source areas.

Alternative 4 would reduce the toxicity, mobility, and volume of groundwater contaminants through treatment but would not actively treat the suspected source of groundwater contamination in the soil. It would employ groundwater extraction and treatment to remediate groundwater contaminants.

5. Short-Term Effectiveness

This criterion pertains to the speed with which the alternative achieves protection as well as the alternative's potential to create adverse impacts on human health and the environment during construction and operation.

None of the alternatives would likely pose risks to human health and the environment during construction and operation. Workers and nearby communities would be protected during site activities by engineering and safety controls. Alternative 4 could achieve protection in the shortest time frame (estimated 10 to 15 years); however, some uncertainty exists regarding the effectiveness of groundwater extraction and treatment in remediating low levels of contamination. Alternative 3 would achieve protection in approximately 15 years.

6. Implementability

This criterion refers to the technical and administrative feasibility of implementing an alternative, including reliability of the remedial technologies and the availability of necessary equipment and personnel.

Alternative 3 could be implemented using existing technologies and readily available services and materials. It would require installation of test wells and performance studies to fully develop treatment effectiveness, and would require off-site waste disposal or recycling.

Alternative 4 could also be implemented using existing groundwater extraction treatment technologies and readily available services and materials. It would also require off-site waste disposal or recycling.

7. Cost

This criterion pertains to the cost of implementing an alternative. Both capital and operations and maintenance costs are considered.

Alternative 3, which includes groundwater monitoring for 20 years and construction and operation of a VES and sparging system for 2 to 3 years, is estimated to cost $2,260,000.

Alternative 4, which includes groundwater monitoring for 15 years and installation of a single barrier cap and groundwater extraction and treatment system, is estimated to cost $14,288,000.

3. Modifying Criteria

Modifying criteria are used in the final evaluation of remedial alternatives.

8. State Acceptance

This criteria refers to whether the State agrees with the selected remedial alternative.

The State concurs with the final remedial alternative described in this ROD. It has been involved throughout the process and its comments have been considered and incorporated throughout.

9. Community Acceptance

This criteria refers to the public support of a given remedial alternative.

Comments received during the public meeting and public comment period were considered during selection of the final remedial alternative. Community response to the remedial alternatives is presented in the Responsiveness Summary, which addresses comments received during the public comment period.

I. THE SELECTED REMEDY

Alternative 3 is the selected remedy. Based on the field investigation, the potential source of groundwater contamination is believed to be the soil hot spots adjacent to the landfill. This alternative is protective of human health and the environment and complies with State and Federal environmental standards. In addition, Alternative 3 is more cost-effective than Alternative 4, while also affording less uncertainty regarding the effectiveness of the treatment technologies.

1. Major Components Of The Selected Remedy

The selected remedy includes treatment of suspected sources of groundwater contamination, treatment of contaminated groundwater, groundwater monitoring, and implementation of institutional controls to protect human health and the environment during remedial action. Major components of the LF4 selected remedy include:

- Installing an active soil VES in suspected groundwater contamination source areas. Vapors from the system will be treated in compliance with air quality regulations prior to discharge.

- Installing an in situ groundwater sparging system to remove volatile contaminants from groundwater. The sparging system will work in conjunction with the VES.

- Monitoring upper aquifer groundwater to determine the effectiveness of the selected remedy.

As part of the monitoring program, the localized area of elevated manganese along the western borders of South and Northwest LF4 will be monitored to determine any changes in manganese concentrations. If the monitoring indicates that manganese concentrations are not declining, the need for remediation of the localized area will then be reevaluated. This reevaluation may include supplemental sampling, or additional source characterization.

- Maintaining institutional controls restricting access to and development at the site as long as hazardous substances remain onsite at levels that preclude unrestricted use.

The goal of this remedial action is to restore groundwater to its beneficial use, which is, at this site, a potential drinking water aquifer. Based on information obtained during the RI and on a careful analysis of all remedial alternatives, the Army, EPA, and Ecology believe that the selected remedy should be able to achieve this goal. The ability to achieve cleanup goals cannot be determined until the VES and groundwater sparging system have been installed, modified as necessary, and contaminant response monitored for approximately 3 years, during which time the system's performance will be carefully monitored on a regular basis and adjusted as warranted by the performance data collected during operation. The specific components of the compliance monitoring program, including points of compliance, will be developed by the Army, EPA, and Ecology during remedial design.

In the event the selected remedy does not approach the remediation goals within three years (based on periodic groundwater sampling data), the need for additional groundwater monitoring, groundwater extraction, capping, or excavation will be reevaluated at that time, consistent with all regulatory requirements appropriate for the alternate remedy that is selected.

2. Remediation Goals

Groundwater cleanup levels have been established to meet State and Federal ARARs which will result in a cumulative risk not to exceed 1×10^{-5}. MTCA Method B was used to determine the cleanup level for VC at 1 ug/l, which is the PQL for the contaminant. The Federal MCL was used to determine the cleanup level for TCE at 5 ug/l.

J. STATUTORY DETERMINATIONS

Under CERCLA Section 121, selected remedies must be protective of human health and the environment, comply with or provide basis for waiver of ARARs, be cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practical. CERCLA also stipulates a preference for those remedies which, as a principal element, significantly and permanently reduce the toxicity, mobility, and volume of hazardous wastes.

1. Protection of Human Health and the Environment

The selected remedy protects human health and the environment through vapor extraction and groundwater sparging of VOC-contaminated soil and groundwater, institutional controls, and groundwater monitoring to ensure remedy effectiveness.

Residual risk at the cleanup levels is 5×10^{-5}, and the residual hazard quotient is below 1. Residual risk exceeds the MTCA goal of 1×10^{-5} because the PQL has a risk associated with it of 5×10^{-5}, but is within the CERCLA acceptable range of 1×10^{-6} to 1×10^{-4}.

2. Attainment of ARARs

The selected remedy of vapor extraction and groundwater sparging will comply with all ARARs of State and Federal regulations.

Action-Specific

- Resource Conservation and Recovery Act (40 CFR 262). Establishes standards for generators of hazardous wastes for the treating, storage, and shipping of wastes. Applicable to the storage, packaging, labeling, and manifesting of the spent granulated activated carbon off-site for treatment.

- Hazardous Materials Transportation Act (49 USC 1801-1813 and 49 CFR Parts 171 and 172). Applicable for transportation of potentially hazardous materials, including samples and wastes.

- Dangerous Waste Regulations (Chapter 173-303 WAC). Applicable for onsite treatment, storage, or disposal of dangerous waste or hazardous waste generated during the remedial action.

- Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 WAC, as modified by Engrossed Substitute House Bill 1806). Relevant and appropriate regulations for the location, design, construction, and abandonment of water supply and resource protection wells.

Chemical-Specific

- Safe Drinking Water Act (40 USC 300 and 40 CFR 141). MCLs for public drinking water supplies are relevant and appropriate for setting groundwater cleanup levels.

- MTCA (Chapter 173-340 WAC). Method B risk-based cleanup levels are applicable for establishing groundwater cleanup levels.

- Resource Conservation and Recovery Act, Subtitle C (40 CFR 261). Applicable in identifying if the spent activated carbon from the carbon adsorption unit is considered a hazardous waste for purposes of transporting them offsite for treatment.

- Ambient concentrations of toxic air contaminants in the Puget Sound region are regulated by the Puget Sound Air Pollution Control Agency (PSAPCA) pursuant to the State of Washington Clean Air Act (Chapter 70.94 RCW) and Implementation of Regulations for Air Contaminant Sources (Chapter 173-403 WAC).

The Best Available Control Technology (BACT) will be required for sources of toxic air contaminants to minimize emissions. The ambient impact of emissions of toxic air contaminants from new sources will be evaluated against Acceptable Source Impact Levels (ASILs) adopted by PSAPCA. Toxic air contaminants are those air contaminants listed in Appendix A of PSAPCA Regulation III or listed in Subpart D, 40 CFR 372. The ASIL for TCE is 0.8 micrograms per cubic meter (g/m[3]) and the ASIL for VC is 0.023 g/m[3].

Location-Specific

- No location-specific ARARs.

Other Criteria, Advisories, or Guidance to be Considered Materials

- EPA OSWER Directive 9834.11, Revised Procedures for Planning and Implementing Offsite Response Actions, November 13, 1987. This directive provides procedures for offsite disposal of CERCLA wastes.

3. Cost Effectiveness

The selected remedy (Alternative 3) is cost-effective because it has been determined to provide overall effectiveness proportionate to its cost and duration for remediation of the contaminated groundwater.

4. Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The Army, EPA, and Ecology have determined the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner for the LF4 site. The principal threats associated with the site are permanently reduced through treatment without transferring the risks to another media. The selected remedy provides the best balance of long-term effectiveness and permanence, reduction in toxicity, mobility, and volume through treatment, short-term effectiveness, implementability, and cost.

5. Preference for Treatment as a Principal Element

The selected remedy satisfies the statutory preference for treatment as principal element by employing VES and sparging for treatment of suspected source areas and contaminated groundwater, respectively.

K. DOCUMENTATION OF SIGNIFICANT CHANGES

The proposed plan for LF4 was released for public comment on May 31, 1993. Public comments on the proposed plan were evaluated at the end of the comment period.

Although no significant changes were made as a result of public comment, an element of the preferred alternative (Alternative 3) was deleted. The groundwater extraction and treatment contingency was deleted because the Army, in consultation with EPA, and Ecology, determined that VES and groundwater sparging systems should be effective at remediating the site in less than three years.

IV. SRCPP

A. SITE NAME, LOCATION, AND DESCRIPTION

The SRCPP occupies an approximately 25-acre area between Sequalitchew Lake and Hamer Marsh, as shown on Figure 2. Most of the SRCPP is relatively flat and surfaced with asphalt or gravel and lies at approximately 240 to 250 feet above MSL. The western end of the facility is lower, approximately 225 to 235 feet above MSL.

Sullivan Well lies approximately 1,800 feet east of the former SRCPP process areas. Sequalitchew Springs lies approximately 2,300 feet northeast of the SRCPP. Both of these features are shown on Figure 2. Other supplemental water supply sources within the study area were discussed in the LF4 Decision Summary.

The majority of the SRCPP facilities were demolished in 1981/1982, but some structures remain. A wastewater treatment facility and fuel storage tanks remain, as do several buildings currently used for light industrial purposes. Surrounding land use is generally recreational. The nearest residential area is located approximately 3,600 feet to the northeast.

There are no known archeological, historical, or cultural resources located on or in the vicinity of the SRCPP. Similarly, no threatened or endangered flora are known to occur on or adjacent to the SRCPP. One federally listed threatened species, the bald eagle, has been observed within the study area; however, bald eagles do not nest on or in the vicinity of the SRCPP.

B. SITE HISTORY AND ENFORCEMENT ACTIVITIES

The SRCPP operated from 1974, until its closure in 1981, as a production/research facility designed to develop a solvent extraction technology for deriving petroleum hydrocarbon-like products from coal. Figure 10 shows historical operation areas.

The SRCPP was initially designed to convert coal into a low-sulfur, low-ash solid (SRC-I) product by the solvent refined coal process. The process was later modified to distill the volatile fractions and produce liquid (SRC-II) fuel products.

Incoming coal was stored in uncovered piles at several locations. Solid products were also stored outside awaiting shipment, as was sulfur (which was produced as a waste). Most process fluids were conveyed throughout the plant via overhead pipes. End products of the SRC-I process included light oil, a wash solvent, a recycled solvent, and a solid. End products of the SRC-II process were fractioned into light, middle, and heavy distillates. These distillates had boiling point ranges similar to gasoline, kerosene, and fuel or motor oils, respectively.

Byproducts of the SRC process included solid, liquid, and gaseous wastes. Solids were reportedly disposed of off site. Liquid wastes were either directed to an on-site wastewater treatment plant or disposed of off site. Contaminants in the solid and liquid wastes included metals, VOCs, SVOCs including polycyclic aromatic hydrocarbons (PAHs), and oil and grease.

Liquid wastes were collected in a system of subsurface drain lines and directed to the wastewater treatment plant. Many of the lines were later shown to have been leaking. Treated wastewater was discharged to the wastewater lagoon. The lagoon was an unlined natural depression located south of the facility. Overflow from the lagoon entered the adjacent Hamer Marsh.

A network of stormwater sewers collected surface water runoff. The runoff was originally directed to surface discharge points north and south of the facility. The runoff reportedly contained PAHs, phenols, metals, coal solids, and other contaminants. Part of the stormwater drain system was later rerouted to the wastewater treatment plant. Currently, most runoff is captured, treated, and routed to the Fort's sanitary sewer system.

In 1979, there was a 2,000-gallon spill of SRC liquid fuel. Subsequent investigations of both soil and groundwater indicated other sources of soil and groundwater contamination might exist at the SRCPP. Available records are limited, but indicate a large volume of contaminated soil was excavated and removed from the spill area in late 1980 and that a groundwater extraction program was instituted to remediate the underlying aquifer. The duration and full scope of this program is not known.

In 1982, sludge in the wastewater lagoon was excavated as part of facility decommissioning. Post-removal sampling indicated PAHs in soils at the base of the excavation. The overflow channel from the lagoon to

Hamer Marsh was subsequently discovered, and soil samples from the Marsh obtained for chemical analysis. Ecology accepted the cleanup as complete in January, 1983, and Hamer Marsh was not remediated.

Beginning in 1981, groundwater and surface water have been monitored at the SRCPP and nearby surface water bodies. This monitoring program was set up as part of the facility decommissioning plan. The Fort Lewis Directorate of Engineering and Housing currently conducts the monitoring.

Historical information indicates SRC wastes, process fluids, and fuels reached the water table during plant operation. Soluble fractions were transported in groundwater downgradient toward Sequalitchew Lake and, to a lesser extent, east toward Sullivan Well. High concentrations of some organic compounds, notably phenol, were detected beneath the SRCPP.

Two investigations were conducted in 1991. The first, an evaluation of plant records, identified several potential contaminant sources within the former process areas. The second included inspecting existing on-site monitoring wells and collecting groundwater samples for chemical analysis. These samples contained low concentrations of PCE and 1,1,1-trichloroethane.

Based on the FFA and the results of previous investigations, an RI/FS was initiated at the SRCPP in 1991. The RI/FS characterized the nature and extent of contamination, assessed site risks to human health and the environment, and evaluated remedial alternatives.

C. SCOPE AND ROLE OF RESPONSE ACTION WITHIN SITE STRATEGY

The selected remedy is intended to address all unacceptable risks resulting from contamination at the SRCPP. It reduces risks associated with potential exposure through excavation and treatment of contaminated soil. Institutional controls are included to prevent construction of new water supply wells within the former SRCPP process area. Long-term groundwater monitoring will verify the effectiveness of the selected remedy.

D. SUMMARY OF SITE CHARACTERISTICS

1. Geology and Hydrogeology

The SRCPP geologic investigation focused primarily on the Vashon Drift. Other deeper deposits were encountered in a lower aquifer monitoring well boring. A description of these deposits is presented in the corresponding LF4 Geology and Hydrogeology section. Recent fill and four distinct Vashon Drift deposits (Steilacoom Gravel, Vashon Recessional Outwash, Vashon Till, and Vashon Advance Outwash) were identified at the SRCPP. The general relationship of these geologic units is shown on Figure 4.

Groundwater beneath the SRCPP generally occurs under unconfined (water table) conditions within Vashon Drift sand and gravel. Depth bgs to the water table ranges from approximately 6 to 42 feet across the site. Although the glacial stratigraphy beneath the SRCPP is quite complex, low-permeability Vashon Till was encountered in many borings at depths of 10 to 20 feet below the water table. This till generally appears to be a local aquitard separating the uppermost groundwater from deeper water-bearing zones.

Hydrogeologic conditions were investigated by installing 14 new upper aquifer wells and 1 lower aquifer monitoring well. These wells supplemented 11 existing, serviceable groundwater monitoring wells.

Groundwater flow beneath the SRCPP is generally from the south to the north and northeast toward Sequalitchew Lake. When Sullivan Well is being pumped, a large cone of depression develops around the well. This cone of depression extends westward between the SRCPP and Sequalitchew Lake and intercepts some of the groundwater flowing beneath the SRCPP. Upper aquifer groundwater ultimately discharges directly into Sequalitchew Lake or is captured by Sullivan Well. Groundwater flow, at the lowest water elevations observed during the study period, is shown on Figure 5.

Hydraulic conductivity of the upper aquifer beneath the SRCPP is estimated to range from approximately 37 to 625 ft/day. Estimated horizontal flow velocities range from approximately 3 to 135 ft/yr. This results in a travel time of approximately 15 to greater than 100 years from former SRCPP process areas to Sullivan Well, the closest water supply source.

The lower aquifer was not characterized beneath the SRCPP. A discussion of lower aquifer characteristics is presented in the LF4 Geology and Hydrogeology section.

2. Nature and Extent of Contamination

The RI investigated potential SRCPP impacts to groundwater, soil, surface water, and Sequalitchew Lake and Hamer Marsh sediments. Air was not investigated because it was determined that the potential for exposure was minimal due to the presence of an extensive asphalt cover, existing structures and the absence of VOCs.

During the RI, there was no evidence to suggest that surface water flowed from the SRCPP into Sequalitchew Lake. Therefore, surface water was not examined.

a. Soil

Soil contamination was investigated by drilling 33 borings and excavating 20 test pits within and around the SRCPP. Additionally, one hand auger boring was installed in the former waste water treatment area. Soil samples were collected from each exploration and submitted for analysis of VOCs (including fuel-range hydrocarbons), SVOCs, and metals. Soil exploration locations are shown on Figure 11. Table 9 summarizes the analytical data for soil samples collected during the RI. Because of the variety of sources and transport mechanisms, contaminant distribution beneath the SRCPP is highly variable and discontinuous in nature. Fuel-range hydrocarbons, SVOCs, and metals characteristic of SRCPP operations were detected in site soils. PCE was also detected at several locations, although it is not specifically associated with any of the SRCPP processes. PCE was likely used as a cleaning solvent during or subsequent to plant operation.

Generally, low concentrations of PAHs were detected throughout the SRCPP, with individual PAH concentrations typically not exceeding 2 milligrams per kilogram (mg/kg). The highest concentrations of PAHs were detected at the waste drain intersection near the center of the process and product storage area, at the tank farm, at the flare knockout drum pad, and in the wastewater treatment area (specifically, near the oil/water separator). The vertical distribution of PAHs was quite variable, with the highest concentrations near the surface in some areas, and near the water table in others. Seven PAHs are carcinogenic; the remainder are noncarcinogenic. All seven carcinogenic PAHs were detected at the SRCPP.

Fuel-range hydrocarbon compounds have a distribution similar to the PAHs, except high concentrations were also detected near the current fueling area southeast of the tank farm. The detections in this area may in part reflect post-SRCPP-closure fuel oil spills. Fuel oil and jet fuel are currently stored and dispensed from the SRCPP tank farm. Leaks and spills from fueling operations have contaminated soils in the area.

Three types of VOCs were detected at low concentrations in SRCPP soil: alkylbenzenes, chlorinated hydrocarbons, and an oxygenated hydrocarbon. Toluene, xylenes, and PCE were most commonly detected. Although these compounds were not as widely distributed as the PAHs, their distribution pattern was similar.

Metals concentrations at greater than background levels occur in the following areas:

- Coal storage area - elevated barium and nickel; all metals were elevated in surface soils at several locations.

- Stormwater outfalls - elevated iron, manganese, arsenic, barium, chromium, lead, nickel, and zinc.

- Process and product storage area - elevated arsenic and zinc; all metals except selenium and thallium are elevated at Test Pit (TP) 3 (at 1 foot), and arsenic, barium, beryllium, chromium, nickel, and zinc are elevated at TP2.

The distribution of contaminants in wastewater lagoon soils indicates the most heavily contaminated soil was removed with the sludge during the 1982 cleanup. Only low concentrations of PAHs and fuel hydrocarbons currently remain, except at the outfall. Soil from this area showed significantly elevated PAH and fuel hydrocarbon concentrations when compared to the other wastewater lagoon soils.

PAHs and fuel hydrocarbons were also detected in Hamer Marsh soil. However, the PAH distribution and fuel fingerprint indicate they are probably derived from a different source. The RI identified stormwater runoff, which passes through the area from the Fort's stormwater treatment facility, as the likely source. Consequently, Hamer Marsh contamination was not considered further in the RI/FS.

b. Groundwater

Groundwater samples were collected from 14 upper aquifer and 11 lower aquifer monitoring wells in April and June 1992. Well locations are shown on Figure 12. The sampling rounds were timed to approximate "wet" and "dry" season conditions. All samples were analyzed for VOCs, SVOCs, PAHs, and total and dissolved metals. A limited third sampling, addressing metals, was conducted in January/February 1993. Table 10 summarizes the analytical results for groundwater samples collected during the RI.

RI results indicate that current SRCPP impacts are generally limited to the vicinity of the former process area. Sullivan Well water shows no discernable impact from SRCPP operations.

RI soil boring data indicate residual SRC product is present at several discrete locations. These hydrocarbons are probably related to historical spills or infiltration related to pipe leaks. RI groundwater quality data, however, indicate few hydrocarbons are being transported in groundwater. Low concentrations (less than 10 ug/l) of PAHs, mostly pyrene and phenanthrene, and VOCs (generally less than 1 ug/l), mostly benzene, ethylbenzene, toluene, TCE, and PCE, were detected in upper aquifer groundwater beneath and downgradient of the SRCPP. Chloroform, which is a by-product of chlorination, was also detected in groundwater.

Metals were also detected in the upper aquifer. Dissolved metals concentrations were either within background ranges or nondetectable, except for sodium, which is typically present in groundwater due to the natural equilibrium between groundwater and geologic materials. Total metals concentrations were also within their background ranges except for lead, which is present at levels significantly above background, at monitoring well 13.

c. Sediment

Sequalitchew Lake sediments were evaluated by collecting five composite shoreline area sediment samples, three from areas immediately downgradient of the SRCPP (S2, S3, S4) and two from areas believed to be unaffected by SRCPP operations (S1, S5). Sequalitchew Lake composite sampling areas are shown on Figure 13. Composite sediment samples were analyzed for VOCs, SVOCs, and metals. Table 11 summarizes the analytical data from the sediment samples collected during the RI.

Sequalitchew Lake sediment samples collected immediately downgradient of the SRCPP have higher metals and PAH concentrations than do sediment samples collected in adjacent areas. The most likely cause of the elevated concentrations is precipitation of metals and scavenging by organic-rich sediments of contaminants from groundwater flowing beneath the SRCPP and discharging to Sequalitchew Lake.

SRCPP impacts to the adjacent wastewater lagoon and Hamer Marsh sediments were investigated by advancing 14 hand auger borings from which soil samples were collected. Hand auger locations are shown on Figure 11. Soil samples were analyzed for VOCs, SVOCs, metals, and fuel hydrocarbons.

Due to the Ecology directed cleanup conducted in 1982, only low concentrations of PAHs and fuel hydrocarbons currently remain in the lagoon, except near the original outfall from the SRCPP. The one sample from this area showed significantly higher PAH and fuel hydrocarbon concentrations.

PAHs and fuel hydrocarbons were also detected in Hamer Marsh sediment. However, the PAH distribution and fuel fingerprint indicate they are probably derived from a different source. Stormwater runoff passing through the area from the Fort's stormwater treatment facility is the likely source.

E. SUMMARY OF SITE RISKS

The Baseline RA for the SRCPP considered human health and ecological risks. The risk assessments were conducted in accordance with EPA's Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual and Volume 2: Environmental Assessment Manual, and EPA national guidance. The RA methods and results are summarized in the following sections.

1. Human Health Risks

The human health RA evaluated potential risks associated with exposure to chemical contaminants from the SRCPP. The assessment considered potential exposure to SRCPP contaminants in soil and groundwater. Air was not included in the quantitative RA because it was determined that the potential for exposure was minimal due to the presence of an extensive asphalt cover, existing structures, and the absence of VOCs. Sediment and surface water was similarly not included because the impacts to Sequalitchew Lake and its sediments are not significant.

Both carcinogenic and noncarcinogenic risks were evaluated. Risks were estimated for current and future land uses in the vicinity of the SRCPP.

To ensure that potential health risks would not be underestimated, a conservative approach was used as recommended in EPA's guidance documents. Reasonable conservative estimates and assumptions were used to enhance confidence in the conclusions of the RA.

a. Identification of Contaminants of Concern

COCs were determined for the SRCPP based on contaminant occurrence and distribution in the environmental media and a risk-based screening approach. The COCs for the SRCPP are shown in Table 12.

b. Exposure Assessment

i. Exposed Populations

Exposure pathways were evaluated for the following receptors:

Current Use:
- Military residents
- SRCPP Facility Employees

Future Use:
- On-site residents
- Adjacent residents

ii. Exposure Pathways

Refer to Table 13 for the exposure pathways evaluated. Predictive modeling indicates a moderate potential for adverse impact from carcinogenic PAHs via leaching to groundwater should site pavements be removed.

iii. Exposure Point Concentrations

Groundwater:

Average and reasonable maximum exposure concentrations were estimated based on field measurements. Groundwater exposure point concentrations were used to quantify the risks due to ingestion of drinking water, dermal absorption during household use, and inhalation of VOCs during household use. Data from different groupings of groundwater wells were used to estimate future exposures. Sullivan Well data were used for current scenarios.

The dissolved fraction of metals in groundwater was used to estimate exposure point concentrations at the SRCPP. Total metal concentrations were considered most representative of silt conditions adjacent to the monitoring wells. Dissolved metal concentrations were considered most representative of exposure point concentrations for the ingestion of groundwater from a water supply well.

Average and reasonable maximum exposure concentrations are listed in Table 14.

Soil:

Average and reasonable maximum exposure concentrations were estimated based on field measurements. Soil exposure point concentrations were used to quantify the risks due to ingestion of soil, dermal contact with soil, and inhalation of fugitive dust. They were also used to estimate concentrations of volatilized VOCs in ambient air for on-site residents. Different groupings of soil analytical data were used to estimate exposure point concentrations. The principal distinction was whether the pavement cover was assumed to be intact or not.

Average and reasonable maximum exposure concentrations are listed in Table 15.

Chemical Intake by Exposure Pathway:

Chemical intakes for each exposure pathway were calculated based on the exposure point concentrations and other exposure parameters such as water ingestion rates, inhalation rates, dermal absorption rates, body weights, exposure frequencies and durations. Reasonable maximum exposure calculations for the SRCPP RA used values from the Standard Default Factors document (OSWER Directive No. 9285.6-03).

c. Toxicity Assessment

The toxicity assessment methodology is as described in the LF4 Toxicity Assessment section. Table 16 lists the toxicity values for the SRCPP COCs.

d. Risk Characterization

The risk characterization integrates the information developed in the toxicity assessment and exposure assessment to characterize the carcinogenic and noncarcinogenic risks associated with contaminant concentrations detected at the SRCPP. Acceptable risk ranges for carcinogens and noncarcinogens are as described in the LF4 Risk Characterization section.

Table 17 provides a summary of estimated health risks for each receptor and pathway.

e. Uncertainty

Carcinogenic and noncarcinogenic health risks were estimated in the RA for the SRCPP using various assumptions. Therefore, the RA results presented in Table 17 contain an inherent amount of uncertainty. The extent to which health risks can be characterized is primarily dependent upon the accuracy with which a chemical's toxicity can be estimated, and the accuracy of the exposure estimates.

Examples of the uncertainty in the exposure and the methodology are as follows:

- VOC chemical concentrations at Sullivan Well were not available. Therefore, concentrations from monitoring wells between the SRCPP and Sullivan Well were used as substitutes. Risk estimates for ingestion of Sullivan Well groundwater in all current scenarios may be overestimated.

- Total metal concentrations were used to characterize future risk due to ingestion of on-site groundwater. Most of the risk calculated is likely due either to background metal concentrations or to particulate matter in the well that would probably not be available in a drinking water supply well.

- Equilibrium partitioning was used to estimate PAH concentrations in groundwater in a future use scenario where the pavement is removed and increased rainwater infiltration and leaching occur. Based on limited existing data from unpaved areas, it appears the estimated concentrations are at least three orders of magnitude higher than current concentrations. This results in a considerable overestimation of the future risk due to ingestion of carcinogenic PAHs in groundwater. However, the risk due to ingestion of these potentially leached chemicals adds only 5 percent to the total cancer risk for ingestion of groundwater.

In addition to these sources of uncertainty, the chemical analytical data base has limitations in such areas as sample locations and sample representativeness. These uncertainties are present in every baseline RA.

2. Ecological Risk Assessment

An ecological RA was conducted to evaluate the potential adverse impacts to plants and animals resulting from exposure to contamination associated with the SRCPP. The results of the ecological RA were intended to support management decisions on whether remedial action is required for environmental protection.

The approach used in the RA is consistent with EPA guidance for evaluating ecological risk. The basic steps were identification of COCs, assessment of potential exposure pathways, and characterization of threats to exposed biota.

a. Exposure Assessment

i. Exposed Populations

Potential receptors were identified as those plant and animal species likely to be exposed to chemicals in Sequalitchew Lake sediments and surface water, soil in the wastewater lagoon, surface soil at the SRCPP. However, the SRCPP provides poor wildlife habitat, thus making the likelihood of significant exposures and toxic effects remote.

No threatened or endangered plant species are known to exist in the SRCPP study area. No threatened or endangered animal species are known to nest within the SRCPP study area; the bald eagle (threatened) and peregrine falcon (endangered) have been observed flying over the area. No critical habitats were identified within the study area.

ii. Exposure Pathways

The exposure assessment identified potential exposure pathways from the chemical source to the affected media, exposure points, and potential receptors. Potential exposure pathways include surface water and sediments in Sequalitchew Lake and soil in the wastewater lagoon. The exposure to lake water and sediments is potentially more serious than soil exposure because of the number of potential receptors and the potential intensity of the exposure.

Groundwater was considered an unlikely pathway because the water table is normally fifteen to twenty feet bgs; consequently ecological receptors cannot come into direct contact with it.

b. Risk Characterization

Qualitative ecological RA results indicated no likely adverse affects as a result of exposure to

SRCPP-derived contaminants. Similarly, quantitative ecological RA Results indicated no likely adverse affects resulting from SRCPP contaminants.

c. Uncertainty

Assumptions that tend to overestimate potential exposure include the following:

- Wildlife species are continuously exposed to maximum contaminant concentrations.

- Contaminants are 100 percent bioavailable.

- Maximum detected groundwater contaminant concentrations discharge to Sequalitchew Lake without attenuation, dilution, or precipitation.

- Published toxicity data for specific fish of wildlife species are applicable to all other fish or wildlife species.

F. REMEDIAL ACTION OBJECTIVES

Remedial action is required at the SRCPP to protect human health and the environment under potential future land use conditions. Action is required because:

- Soils beneath the site are contaminated with carcinogenic PAHs at levels exceeding State regulatory requirements.

- Carcinogenic PAHs in soil have the potential, if site pavements are removed, to adversely impact groundwater. Predictive modeling indicates risks from impacted groundwater could exceed MTCA risk goals.

Arsenic, beryllium, and PCE are not included because they were detected at concentrations that are below regulatory cleanup levels. Chloroform is not included because it is thought to be present as a drinking water chlorination by-product. Manganese is also not included because it is confined to a localized area and it is expected to rapidly decline due to implementation of the final remedy, as described in The Selected Remedy section.

Contaminated soil requires action. RAOs were formulated to protect human health and the environment from potential threats associated with site contaminants. RAOs for the SRCPP include:

- Prevent exposure to contaminated soils.

- Prevent movement of contaminants from soil to groundwater.

- Prevent exposure to contaminated upper aquifer groundwater beneath the former SRCPP.

Soil cleanup levels have been established to meet regulatory requirements. MTCA Method B was used to set the cleanup level for PAHs at 1.0 mg/kg.

G. DESCRIPTION OF ALTERNATIVES

The remedial alternatives for the SRCPP were divided into two groups: those addressing soil and those addressing groundwater. The preferred alternative of each group is combined to form a single cleanup action following the individual evaluations.

Regardless of the alternative selected, portions of the SRCPP will be demolished incidental to cleanup actions implemented at the site. Demolition costs are not included in alternative costs, and may include all industrial process lines, tanks, and structures, as well as remaining plant buildings not currently used for other purposes.

<u>1. Soil Cleanup Alternatives</u>

Soil Alternative 1: No Action

Under this alternative, which is presented as a baseline for comparison against other alternatives, no action would be taken. This alternative assumes continued light industrial site use. The cleanup of soil contamination would only occur through natural processes. Because of the variety of contaminants in the soil, it is estimated that these natural processes would require more than 50 years to achieve State environmental standards. Present worth costs are estimated at $0.

Soil Alternative 2: Institutional Controls

This alternative includes institutional controls such as access restrictions and land use restrictions. This alternative assumes continued light industrial site use. It is estimated that natural processes would require more than 50 years to achieve State environmental standards. Present worth costs are estimated at $29,000.

Soil Alternative 3: Asphalt Cap

This alternative includes institutional controls and paving uncovered operational areas with asphalt. This alternative assumes continued light industrial site use. The asphalt cap would protect site users against contact with contaminated soils or dust. It would also inhibit leaching of carcinogenic PAHs from soil to groundwater.

Pavement would be placed in currently unpaved areas within the former SRCPP process area: approximately 5 acres would require paving. All vegetation would be removed and the soil would be sterilized. Site soils would be graded and unsuitable areas removed and replaced.

Carcinogenic PAHs in soil would naturally degrade over time due to biological processes. However, the time frame to meet cleanup levels would likely be greater than 50 years. Present worth costs are estimated at $357,000.

Soil Alternative 4: Single Barrier Cover

This alternative is similar to Alternative 3, with the exception that a single barrier cover and soil layers would be installed over the operations area in place of the asphalt layer. This alternative would allow for recreational use of the SRCPP site. The cover would inhibit contaminates from being leached into the groundwater. Institutional controls would be used to insure maintenance of the cover and to prevent exposure to soil contaminants.

Carcinogenic PAHs in soil would naturally degrade over time due to biological processes. However, the time frame to meet cleanup levels would likely be greater than 50 years. Present worth costs are estimated at $1,839,000.00.

Soil Alternative 5: Soil Excavation and Treatment

Contaminated soil would be excavated from the former process area and tank farm, and treated by either soil washing or thermal destruction technologies. The approximate extent of soil excavation is shown on Figure 14. A treatability study would determine which technology is chosen. Following treatment, the site would be backfilled with the treated soil and revegetated. This alternative, which would allow for unrestricted use, would protect human health and the environment by removing and treating contaminated soil, thus protecting groundwater by removing potentially leachable contaminants from the soil.

Conceptual design estimates indicate a range of approximately 30,000-80,000 cubic yards of contaminated soil would require removal and treatment.

Soil washing would extract contaminants from the soil matrix using a washing solution and spray or mixing equipment. Thermal destruction of soil contaminants would likely employ low temperature thermal desorption. Treatment residuals would be disposed of at an EPA-approved off-site disposal or recycling facility. The time required to achieve State environmental standards is estimated to be less than 2 years. Assuming a soil washing treatment technology is chosen, present worth costs are estimated at $4,776,000.

<u>2. Groundwater Cleanup Alternatives</u>

Groundwater Alternative 1: No Action

The no action alternative is presented as a baseline for comparison to other groundwater alternatives. Under this alternative, no action would be taken to reduce groundwater contamination. A monitoring program would be implemented to monitor groundwater contamination. It is estimated that contaminant concentrations would decrease to acceptable levels due to natural processes in approximately 50 years. Present worth costs are estimated at $80,000.

Groundwater Alternative 2: Institutional Controls

With this alternative, groundwater monitoring would continue and institutional controls would be implemented. Institutional controls may include access restrictions and/or further land use restrictions, in addition to existing Fort Lewis groundwater well installation restrictions. It is estimated that contaminant concentrations would decrease to acceptable levels due to natural processes in approximately 50 years. Present worth costs are estimated at $81,000.

Groundwater Alternative 3: Groundwater Extraction and Treatment

This alternative includes groundwater monitoring, institutional controls, and groundwater extraction and treatment. Eight extraction wells would be installed and the extracted groundwater would be treated to remove contaminants. Contaminated groundwater would be treated using a carbon filter unit. Treatment residuals would be disposed of at an off-site

EPA-approved disposal or recycling facility. Treated water would be discharged either to Sequalitchew Lake or groundwater recharge trenches, dependent on cost and implementability. State drinking water standards would be achieved in 10 to 20 years. Present worth costs are estimated at $9,400,000.

H. SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, each soil alternative is compared against each other soil alternative, and each groundwater alternative is compared against each other groundwater alternative. This comparison uses the nine evaluation criteria presented in the LF4 Summary of Comparative Analysis of Alternatives section.

1. Comparative Analysis of Soil Alternatives

a. Threshold Criteria

1. Overall Protection of Human Health and the Environment

Alternatives 1 and 2 would not provide protection from potential contaminants nor prevent contaminant migration within a reasonable time frame. It is not reasonable to encumber the use of this property for this time frame, given adjacent industrial and recreational uses and the potential for future industrial or recreational development. Thus alternatives 1 and 2 are not protective of human health and the environment.

Alternatives 3 and 4 prevent physical contact with soil contaminants and reduce the potential for these contaminants to affect groundwater, but do not reduce or remove the contaminants from the soil.

Alternative 5 offers the most protection to human health and the environment. It reduces contaminant levels, prevents future degradation of groundwater quality, and would be most protective of future site and groundwater use.

2. Compliance with ARARs

Alternatives 1 and 2 may attain State soil cleanup levels through natural processes. However, these levels would not be achieved within a reasonable time frame and in the interim, soil contaminant levels would continue to exceed State soil standards.

Alternatives 3, 4, and 5 would achieve compliance with ARARs and would not require waivers.

b. Primary Balancing Criteria

Alternatives 1 and 2 do not satisfy the threshold criteria since they do not provide adequate protection of human health and the environment nor comply with Federal and State environmental standards within a reasonable time frame. Because these alternatives do not satisfy threshold criteria, they are not considered further in this analysis as an option for site remediation.

3. Long-Term Effectiveness and Permanence

Alternatives 3 and 4 would require enforcement of existing institutional controls, and routine inspection and maintenance of cover.

Alternative 5 allows for unrestricted future use.

4. Reduction in Toxicity, Mobility, and Volume through Treatment

Alternatives 3 and 4 control direct exposure to contaminants, but do not treat contaminated soil.

Alternative 5 offers the greatest reduction in toxicity, mobility, and volume by removing and treating the soil contaminants.

5. Short-Term Effectiveness

None of the alternatives would likely pose risks to human health and the environment during construction and operation. Workers and nearby communities would be protected during site activities by engineering and safety controls.

Alternative 5 may require additional controls to protect workers from dust generated during construction and would achieve protection in the shortest time frame (within 2 years).

6. Implementability

All alternatives use readily available services and materials. Because of the variety of contaminants, Alternative 5 requires treatability studies to determine the appropriate treatment technology.

7. Cost

Alternative 3, which includes placement of additional asphalt cover and long-term maintenance of the site, is estimated to cost $357,000. Alternative 4, including design and construction of a single barrier cover and associated long-term maintenance, is estimated to cost $1,839,000.

Alternative 5, with an estimated cost of $4,776,000, is the most expensive.

c. Modifying Criteria

8. State Acceptance

The State concurs with the final remedial alternative described in this ROD. It has been involved throughout the process and its comments have been considered and incorporated throughout.

9. Community Acceptance

Comments received during the public meeting and public comment period were considered during selection of the final remedial alternative. Community response to the remedial alternatives is presented in the Responsiveness Summary, which addresses comments received during the public comment period.

2. Comparative Analysis of Groundwater Alternatives

a. Threshold Criteria

1. Overall Protection of Human Health and the Environment

Alternative 1 would not provide protection from potential contaminants nor prevent contaminant migration within a reasonable time frame. It is not reasonable to encumber the use of this property for this time frame, given adjacent industrial and recreational uses and the potential for future industrial or recreational development. Thus, Alternative 1 is not protective of human health and the environment.

Alternative 2 would provide adequate protection only in conjunction with Soil Alternatives 3, 4, or 5. These combinations would manage soil contaminants so that they do not impact groundwater.

Alternative 3 would provide adequate protection by extracting and treating contaminated groundwater, assuming that soil contaminants leached into the groundwater.

2. Compliance with ARARs

Alternative 1 may attain State groundwater cleanup levels through natural processes. However, these levels would not be achieved within a reasonable time frame and in the interim, groundwater contaminant levels would continue to exceed State groundwater standards.

Alternatives 2 and 3 meet ARARs and do not require waivers.

b. Primary Balancing Criteria

Alternative 1 does not satisfy the threshold criteria since it does not provide adequate protection of human health and the environment nor comply with environmental standards within a reasonable time frame. Because this alternative does not satisfy threshold criteria, it is not considered further in this analysis as an option for site remediation.

3. Long-Term Effectiveness and Permanence

Alternative 2, in conjunction with Soil Alternative 3, 4, or 5, would control the suspected source of groundwater contamination, thus providing long term protection. Although alternative 3 offers protection of groundwater by extracting and treating contaminated groundwater, it does not address the suspected source of groundwater contamination.

4. Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 2, when combined with Soil Alternatives 3, 4, or 5, would reduce the toxicity, mobility, and volume of contaminated groundwater by controlling or removing the potential source of groundwater contamination.

Alternative 3 would reduce the toxicity, mobility, and volume of contaminated groundwater, particularly if soil contaminants are allowed to leach into groundwater.

5. Short-Term Effectiveness

None of the alternatives would likely pose risks to human health and the environment during construction and operation. Workers and nearby communities would be protected during site activities by engineering and safety controls.

6. Implementability

Alternative 2 could be easily implemented.

Alternative 3 could be implemented using existing technologies and available services and materials, but would require substantial engineering and design.

7. Cost

Alternative 2 is substantially less expensive than alternative 3.

c. Modifying Criteria

8. State Acceptance

The State concurs with the final remedial alternative described in this ROD. It has been involved throughout the process and its comments have been considered and incorporated throughout.

9. Community Acceptance

Comments received during the public meeting and public comment period were considered during selection of the final remedial alternative. Community response to the remedial alternatives is presented in the Responsiveness Summary, which addresses comments received during the public comment period.

I. THE SELECTED REMEDY

The selected remedy combines Soil Alternative 5 (excavation and treatment) and Groundwater Alternative 2 (institutional controls). This combined alternative is selected because it protects the groundwater from future contamination by excavating and treating the suspected source of groundwater contamination. Excavated soils would be treated to the State soil cleanup standards.

The groundwater monitoring program and periodic reviews would evaluate the selected remedy's effectiveness. These reviews would determine what additional actions, if any, would be appropriate.

1. Major Components of the Selected Remedy

Major components of the selected remedy include:

- Excavating and treating contaminated soils. Soils will be treated using either soil washing or thermal destruction to meet cleanup levels.

- Monitoring upper aquifer groundwater beneath and adjacent to the site to determine the effectiveness of soil treatment.

- Maintaining institutional controls restricting access to and development at the site as long as hazardous substances remain onsite at levels that preclude unrestricted use.

The goal of this remedial action is to restore groundwater to its beneficial use, which is, at this site, a potential drinking water aquifer. Based on information obtained during the RI and on a careful analysis of all remedial alternatives, the Army, EPA, and Ecology believe that the selected remedy would be able to achieve this goal.

2. Remediation Goals

Soil cleanup levels have been established to meet the State ARARs which will result in a cumulative risk not to exceed 1 x 10[-5]. MTCA Method B was used to set the SRCPP soil cleanup level for total carcinogenic PAHs at 1.0 mg/kg.

The following seven carcinogenic PAHs were identified as soil contaminants during the RI: benzo(a)anthracene; benzo(b)fluoranthene; benzo(k)fluoranthene; benzo(a)pyrene; chrysene; dibenzo(a,h)anthracene; and ideno(1,2,3cd)pyrene.

The approximate extent for the point of compliance for soil remediation is throughout the site (as shown by the shaded area on Figure 14) from the ground surface extending vertically to the uppermost level of the saturated zone. The point of compliance for groundwater, and the specific components of the compliance monitoring program for soil and groundwater will be developed by the Army, EPA, and Ecology during remedial design as part of the Remedial Action Management Plan.

The monitoring program for groundwater may include only PAHs, manganese, and field parameters. PAHs and manganese will be evaluated against their corresponding groundwater cleanup standards, which are 0.1 ug/l and 80 ug/l, respectively. If the monitoring indicates that PAHs or manganese exceed action levels, the need for remediation will be reevaluated. This reevaluation may include supplemental sampling or additional source characterization.

On a periodic basis, the following groundwater indicator parameters may also be sampled and analyzed for: calcium, magnesium, potassium, sodium, bicarbonate, chloride, sulfate, nitrate, oxygen, nitrogen, silica, and iron.

In addition, because of the potential for process leaks or surface spills at the tank farm, total petroleum hydrocarbons will also be analyzed for in the groundwater in proximity to the tank farm. This contaminant will be evaluated against its State of Washington groundwater cleanup standard of 1000 ug/l.

J. STATUTORY DETERMINATIONS

Under CERCLA Section 121, selected remedies must be protective of human health and the environment, comply with or provide basis for waiver of ARARs, be cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practical. CERCLA also stipulates a preference for those remedies which, as a principal element, significantly and permanently reduce the toxicity, mobility, and volume of hazardous wastes.

1. Protection of Human Health and the Environment

The selected remedy protects human health and the environment through excavation and treatment of contaminated soils, institutional controls, and groundwater monitoring to insure remedy effectiveness.

Residual risks at the cleanup levels are 7 x 10[-6]. This is below the MTCA site-wide risk goal of 1 x 10[-5] and is also within the CERCLA acceptable range of 1 x 10[-6] to 1 x 10[-4].

2. Attainment of ARARs

The selected remedy of soil excavation and treatment will comply with all ARARs of State and Federal regulations.

Action-Specific

- Resource Conservation and Recovery Act (40 CFR 262). Establishes standards for generators of hazardous wastes for the treating, storage, and shipping of wastes. Applicable to the storage, packaging, labeling, and manifesting of the waste residuals off-site for treatment.

- Hazardous Materials Transportation Act (49 USC 1801-1813 and 49 CFR Parts 171 and 172). Applicable for transportation of potentially hazardous materials, including samples and wastes.

- Dangerous Waste Regulations (Chapter 173-303 WAC). Applicable for onsite treatment, storage, or disposal of dangerous waste or hazardous waste generated during the remedial action.

- Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 WAC, as modified by Engrossed Substitute House Bill 1806). Relevant and appropriate regulations for the location, design, construction, and abandonment of water supply and resource protection wells.

- Ambient concentrations of toxic air contaminants in the Puget Sound region are regulated by PSAPCA pursuant to the State of Washington Clean Air Act (Chapter 70.94 RCW) and Implementation of Regulations for Air Contaminant Sources (Chapter 173-403 WAC). The BACT will be required for sources of toxic air contaminants to minimize emissions. The ambient impact of emissions of toxic air contaminants from new sources will be evaluated against ASILs adopted by PSAPCA.

Chemical-Specific

- MTCA (Chapter 173-340 WAC). Method B risk-based cleanup levels are applicable for establishing soil and groundwater cleanup levels.

- Resource Conservation and Recovery Act, Subtitle C (40 CFR 261). Applicable in identifying if soil treatment residuals are considered a hazardous waste for purposes of transporting them off-site for treatment.

Location-Specific

- No location-specific ARARs.

Other Criteria, Advisories, or Guidance to be Considered Materials

- EPA OSWER Directive 9834.11, Revised Procedures for Planning and Implementing Offsite Response Actions, November 13, 1987. This directive provides procedures for offsite disposal of CERCLA wastes.

3. Cost Effectiveness

The selected remedy (soil alternative 5 and groundwater alternative 3) is cost-effective because it has been determined to provide overall effectiveness proportionate to its cost and duration with respect to both soil and groundwater.

4. Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The Army, EPA, and Ecology have determined the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner for the SRCPP. The principal threats associated with the site are permanently reduced through treatment without transferring the risks to other media. The selected remedy provides the best balance of long-term effectiveness and permanence, reduction in toxicity, mobility, and volume through treatment, short-term effectiveness, implementability, and cost.

5. Preference for Treatment as a Principal Element

The selected remedy satisfies the statutory preference for treatment as principal element by actively treating contaminated soils.

K. DOCUMENTATION OF SIGNIFICANT CHANGES

The proposed plan for the SRCPP was released for public comment on May 31, 1993 Public comments on the proposed plan were evaluated at the end of the comment period, and it was determined that no significant changes to the proposed plan were necessary.

RESPONSIVENESS SUMMARY

The public comment period on the Proposed Plan for both LF4 and the SRCPP was held from May 31 to June 30, 1993. Three sets of written comments were received and are included in Appendix A.

A public meeting was held on June 15, 1993 to explain the Proposed Plan and solicit public comments. Ten members of the public attended the meeting. Two members of the public participated in a discussion following the presentation. Both offered support for the selected remedies. The transcript of the public meeting is available in the Administrative Record.

This summary is a response to items raised in the written comments.

1. Comment:

A letter was received expressing support for the selected remedies for each site.

Response:

The proposed remedies are believed to be the best available compromise to address the hazards posed by the sites.

2. Comment:

A letter was received expressing no opinion regarding LF4, but did express the opinion that no remedial action be undertaken at the SRCPP.

Response:

CERCLA requires the consideration of future site use in determining the selected remedy. It was determined as part of the investigative process and the baseline risk assessment that an unacceptable future risk exists due to ingestion of, inhalation of fugitive dust from, and direct contact with contaminated soil at the SRCPP. In addition, contaminated soil represents a likely source of potential groundwater contamination should site pavements be removed.

Therefore, the final remedial action is warranted because it will be protective of human health and the environment, and will restore the site for unrestricted future use within a reasonable timeframe.

3. Comment:

A letter was received expressing no opinion regarding the SRCPP but did comment on the preferred alternative for LF4. This party indicated that the preferred alternative should include capping of the landfill.

Response:

Although capping was considered, it was not included in the preferred alternative because:

- Contaminant distribution patterns in groundwater and soil gas indicate principal sources of groundwater contamination are located outside the landfill.

- Aerial photographs indicate historical disposal activities outside the landfill boundaries.

For these reasons, it is believed that capping the landfill would not decrease groundwater contamination or provide substantially more protection of human health and the environment. Furthermore, capping the landfill is not likely to provide sufficient incremental increase in protectiveness relative to the increase in cost. A 5-year review will be conducted; remedy effectiveness will be evaluated at this time. Should evaluation indicate the remedy is not providing adequate protection of human health and the environment, other potential remedial actions, including excavation and capping, will be evaluated.

List of Acronyms and Abbreviations

ARARs - applicable or relevant and appropriate requirements
Army - U.S. Army
ASIL(s) - Acceptable Source Impact Level(s)
BACT - Best Available Control Technology
bgs - below ground surface
CERCLA - Comprehensive Response, Compensation, and Liability Act of 1980
COC(s) - contaminant(s) of concern
CRP - community relations plan
DCE - dichloroethene
Ecology - Washington State Department of Ecology
EPA - U.S. Environmental Protection Agency
FFA - Federal Facility Agreement
Fort - Fort Lewis Military Reservation
FS - feasibility study
ft/day - feet per day
ft/yr - feet per year
HI - Hazard Index
LF4 - Landfill 4
MCL(s) - maximum contaminant level(s)
mg/kg - milligrams per kilogram
mg/m[3] - milligrams per cubic meter
MSL - Mean Sea Level
MTCA - Washington State Model Toxics Control Act
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
PAH(s) - polycyclic aromatic hydrocarbon(s)
PCE - tetrachloroethene
PNL - Battelle's Pacific Northwest Laboratory
PQL - practical quantitation limit
PSAPCA - Puget Sound Air Pollution Control Agency
RA - risk assessment
RAOs - remedial action objectives
RfD(s) - reference dose(s)
RI - remedial investigation
RI/FS - remedial investigation/feasibility study
ROD - Record of Decision
SF(s) - slope factor(s)
SRCPP - Solvent Refined Coal Pilot Plant
SVOC(s) - semivolatile organic compound(s)
TCE - trichloroethene
TP - Test Pit
ug/l - micrograms per liter
ug/m[3] - micrograms per cubic meter
VC - vinyl chloride
VES - vapor extraction system
VOC(s) - volatile organic compound(s)

APPENDIX A

PUBLIC COMMENTS ON PROPOSED PLAN

Office of Administration
Mayor Janda Volkmer

June 7, 1993

HQ I Corps and Fort Lewis
ATTN: AFZH-DEQ (Ms. Wofford)
Fort Lewis, WA 98433-5000

Dear Ms. Wofford,

I have read the informational report concerning the proposed plan for cleaning the sites identified as Landfill 4 and the Coal Pilot Plant. While there is considerable distance separating the Town of Steilacoom and these sites the environmental contamination is still of great concern to the Town.

In seeking the preferred alternative for the cleaning of these sites, the Town of Steilacoom recognizes the importance that time and money play in the making of these decisions. However, the Town strongly recommends that the method which will remove contaminates and/or cleans the soils be selected as the preferred alternative. The Town of Steilacoom obtains all of its water from wells located within our community; however, Fort Lewis and the Town of Steilacoom share the same aquifer. Environmental contamination on Fort Lewis has the potential of impacting our water supply.

The protection of safe and clean drinking water for our community is of importance to the Town of Steilacoom. For this reason the Town would recommend a method which would best protect the water supply for both Fort Lewis and the Town of Steilacoom. The Town of Steilacoom supports the preferred alternatives as recommended in your May 1993 report.

Sincerely,

Steven Fischer
Planner

15 june 93

HQ I Corps and Ft.Lewis
Fort Lewis, WA 98433-5000

Sir:

I'm delighted to comment on the proposed cleanup of the site of the Coal Pilot Plant at Ft.Lewis.

I just returned from ten days spent In the coal region of Pennsylvania, namely in Coal and Zerbe Townships.

I'd guess the so-called "Problems" at Ft.Lewis are infinitesimal compared with the scope present in the two townships mentioned.

Yet, without any outside aid, nature has reclaimed the affected area, and the White Poplar and Red and River Birch are flourishing.

I fervently hope no clean up be undertaken. Unless, of course, the treasury is overflowing and the surplus must be spent.

Sincerely,

(b)(6)

6-3-93

Dear Ms. Wofford;

I just wanted to share this article with you. I have followed the landfill stories in the Morning News Tribune and I am really concerned about our soil and groundwater in Pierce County! I am also concerned that Pierce County Executive Doug Sutherland wants to pursue the idea of additional landfills on Fort Lewis property!

After reading the enclosed article - the only option is to:

- Soil treatment, (by vapor extraction) groundwater treatment, (by sparging) capping the landfill and treating contaminated groundwater

- monitoring & institutional controls implemented immediately!

Before its too late we need to act conscientiously!!

Sincerely, (b)(6)

Ground water too precious not to protect

By Tom Arrandale

It's hard to find a local-government official be thrilled to learn that the federal Superfund program is coming to town to clean up toxic pollution. That makes it even more difficult to fathom why local governments still aren't doing all they can to guard vulnerable ground-water supplies against future Superfund fiascoes.

Underground aquifers supply the drinking water for half the American people. If nothing else, Superfund has demonstrated how costly it can be to clean up those crucial resources once they've been contaminated.

At most toxic waste sites, chemicals pose the most serious threats when they seep downward toward water tables. Yet many states have barely begun drafting comprehensive groundwater management plans or even locating and mapping the aquifers that are at risk of contamination.

And many communities still shy away from managing how land is used above irreplaceable ground-water resources.

Across most of the country, the feeling persists that "you can just put something down a hole in the ground and not pay any price for it," says Michel J. Paque, executive director of the Ground Water Protection Council.

Indeed, we've always treated ground water as a cheap and conveniently invisible cesspool. Oil-drilling operations and many industrial plants have been injecting contaminant-laced fluids into the ground through wells drilled for that purpose. Gasoline and other storage tanks leak petroleum and chemicals, while fertilizers and pesticides from farmlands and golf courses seep through permeable soils. Human wastes flowing through poorly located septic tanks have been contaminating the water beneath semirural subdivisions.

All too often, we've built those homes and industrial plants in river valleys and other places where ground water lies closest to the surface. The U.S. Environmental Protection Agency has found that manmade chemicals have contaminated roughly 20 percent of the country's drinking water aquifers.

In New Jersey alone, more than 5,000 domestic wells and close to 200 public water-supply wells have been contaminated by polluted ground water.

New Jersey, along with Massachusetts, Florida and other industrial states, has established protected zones surrounding drinking water wellheads or soil formations where rainfall seeps into the ground to recharge aquifers.

Those programs put the most sensitive areas off limits to landfills, hazardous waste dumps and other clearly dangerous facilities. They also require industrial plants to install double-walled fuel tanks and backup systems that will catch spilled chemicals in the event of accident.

Taking another approach, Iowa in 1987 launched an innovative program encouraging farmers to voluntarily cut back on using chemicals that can find their way into aquifers.

Other states have been lagging behind. The Association of State and Interstate Water Pollution Control Administrators suggests diverting Superfund money to help states come up with comprehensive ground-water policies. Just before leaving office, former EPA Administrator William K. Reilly approved guidelines for states to follow in setting up comprehensive groundwater management programs.

It's now clear that ground-water and surface-water systems are closely related, and Congress should set clear national goals for protecting both, preferably on a watershed-by-watershed basis. But protecting ground water eventually comes down to regulating land use, and local governments need to take the initiative.

Prodded by state laws and potential financial liability, cities and counties around the country are now closing down leaking landfills, but governments should also be steering industrial and residential growth away from sensitive groundwater systems.

Austin, Texas, and Clarke County, Va., have imposed comprehensive land-use restrictions precisely for that purpose. To keep from contaminating an aquifer supplying drinking water to Spokane, the five-county Panhandle Health District in northern Idaho banned septic tanks on lots of less than 5 acres in Kootenai County and ordered subdivisions to contain all runoff from storm water. That, in effect, is forcing development closer to existing sewage treatment systems serving Coeur d'Alene and other towns.

"We cannot afford not to prevent contamination," contends Kenneth W. Lustig, the district's environmental health director, "because we cannot afford to clean it up."

Yet around the country, most local government leaders still don't seem to comprehend the connection between regulating how land is used and protecting water.

Two decades ago, it took the Cuyahoga River in Cleveland catching fire to persuade Congress to pass the Clean Water Act to remove pollution from lakes and streams. Today's Superfund morass is not quite that dramatic, but it should be all the warning communities around the country need that it's time to keep the same thing from happening to ground water.

Tom Arrandale writes for Governing Magazine.